



CONSUMPTION OF SMOKE.

COPY OF A LETTER

ADDRESSED TO HER MAJESTY'S SECRETARY OF STATE FOR
THE HOME DEPARTMENT, BY THE

GENERAL BOARD OF HEALTH,

DATED 20TH JULY 1854 ;

WITH A DIGEST

OF THE

INFORMATION OBTAINED WITH REGARD TO THE OPERATION

OF

INVENTIONS FOR THE CONSUMPTION OF SMOKE.

Her Majesty's Secretary of State

PRESENTED TO BOTH HOUSES OF PARLIAMENT BY COMMAND OF HER MAJESTY.

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REPORT.

T. TAYLOR, Esq. to VISCOUNT PALMERSTON, G.C.B.

GENERAL BOARD OF HEALTH, WHITEHALL,
July 20. 1854.

MY LORD,—I am directed by the General Board of Health to enclose, for the information of your Lordship, a digest of the information with regard to the operation of inventions for the consumption of smoke, which has been elicited by the inquiries of the Board among persons who have employed inventions for this purpose.—I have, &c.,

(Signed) T. TAYLOR, Secretary.

Viscount Palmerston, G.C.B., &c., &c., &c.

In accordance with the request of Viscount Palmerston, conveyed in Mr Fitzroy's letter of the 31st day of October 1853, the Board have instituted very extensive inquiries among those acquainted with the means for the prevention of smoke. * * * *

From the evidence obtained, it appears that smoke has been entirely prevented, in many cases, in that large class of furnaces used for boiling, as for steam-engines, brewers and dyers' pans, &c., without any alteration of the furnace, where it had in the first instance been well constructed and carefully attended to, and that it is easy very considerably to diminish the smoke commonly emitted from such furnaces without any extraordinary care, by alterations neither expensive nor troublesome, if the furnace is not very badly constructed.

It also appears, from this evidence, that in many such cases smoke has been prevented by good stoking *alone*, and by slightly opening the furnace door after putting on coal, and that smoke from all furnaces may be much more greatly

diminished. If to good stoking be added one of the many contrivances for admitting air above or beyond the fuel, smoke may be very generally prevented, except when the fire is first lighted, and for short intervals after adding fresh fuel.

It also appears that where particular circumstances have rendered the prevention of smoke from bituminous coal difficult, many manufacturers have found it advantageous to resort to the use of smokeless fuel, that produces no more smoke than can readily be consumed.

It also appears that smoke from almost all fires, such as those for warming rooms and cooking, for bakers' ovens and pottery kilns, may be very considerably diminished and in many cases entirely prevented; for that has been accomplished in several instances of each of the different kinds of fire.

Besides the information thus derived from a large number of persons interested in inventions for the prevention of smoke, the Board have also received returns from fifty-six firms which have adopted various means for the diminution of smoke. These returns refer to a far larger number of furnaces than fifty-six, as most of the firms in question use several furnaces. From this table it will be seen that, in almost all these cases, very considerable success has attended the efforts to reduce smoke. The reply to the question, "Have you succeeded in diminishing smoke?" has in twenty-three cases been simply "yes;" in eighteen other cases the answer is to the same effect, *e. g.* "almost entirely," "not more smoke than a private house," "completely, except when the fire is first lighted." Others seem to have been less completely successful, and make such replies to the question as "partially," "considerably," "yes, to some extent," &c.

Three only of those to whom queries were addressed seem to have entirely failed.

After such instances of success it is impossible to deny that smoke may be prevented. Numerous cases indeed of partial and some of complete failure have occurred, but these only shew that proper means have not been used, or that the means employed have not been adapted to the particular cases.

It has been commonly asserted that the requisite heat cannot be maintained without producing smoke; this difficulty has been experienced by only eight of the fifty-six firms which have sent returns. Some state that the difficulty has been slight, others that increased heat has been occasioned in equal time with less fuel, and this, indeed, appears to be the usual result.

The effect upon the consumption of fuel has not been accurately observed, but in a large majority of cases a considerable saving has been effected. In twelve only of the fifty-six has

there been no saving; in three consumption has increased; in nine cases it is stated not to have been ascertained; in thirty-five the saving is variously estimated from five to fifty per cent. The explanation of this great disparity appears to be, that means for the prevention of smoke have often been accompanied by changes in the boiler, which may have been the chief cause of the saving. In other cases smoke has been prevented by admitting air in excess, which has carried off part or all of the additional heat produced by more perfect consumption.

The degree in which the prevention of smoke has been effected is also various.

Unexceptionable experiments show that in some instances it has been all but perfect, while in these cases there has been at the same time a great saving of fuel. Mr Houldsworth, of Manchester, for example, with Williams's Argand furnace, has obtained a saving of from ten to twenty-five per cent., and sometimes even from twenty-five to thirty-five per cent. A saving of one half of the fuel now used might be obtained by altering some of the worst furnaces and boilers into the best.

Messrs Dirk and Co., who state that the furnace for which they were agents (namely Williams's expired patent of 1839) has been successfully introduced in above 2000 cases. This is one of the many plans, and perhaps the best, for admitting air beyond the fuel. It has been highly recommended, apparently justly, both for its scientific and practical merits.

G. F. Wilson, of Price's Patent Candle Company, reports that their Company succeeded in preventing smoke by using anthracite coal with a fan, but when the supply of that coal became irregular and costly they resorted, with complete success, to various patented processes. They now use successfully Jukes's, Hall's, and Hazeldine's furnaces, three patented methods for carrying the coal slowly from the front to the back of the furnace. At Liverpool the Company has fourteen furnaces of thirty-five horse power each, and nineteen at Vauxhall and Batterséa, all, it is stated, giving perfect results.

"You will not wonder after the above," adds Mr Wilson, "that it seems odd to us to hear of the impossibility of consuming smoke, and to see people so regardless of their pockets sending good fuel up their chimneys."

Mr Wilson regards these three inventions as so nearly equal in utility, that he would be guided in his choice of either by their cost and durability. "Our smoke consumers," he says, "do as much work with small coal as the old furnaces did with large." The saving with the same fuel appears to be about twelve per cent.

At Messrs Truman, Hanbury and Buxton's, brewers, Jukes's

furnace has been used for four years, with great economy and success. Twenty years ago, viz., May 24. 1834, a patent on a similar principle was granted to Captain Bodmer, an eminent engineer of Manchester.

Samuel Hall's patent has been successfully worked in many instances, among others, at Woolwich Dockyard. It is said to be expensive.

The use of smokeless fuel has been adopted by many persons as best adapted for their particular cases. Welsh coal, coke, and various patent fuels are used. These act by producing very little smoke, and that little is more easily prevented than under ordinary circumstances, but unless there is sufficient quantity of air above the fuel, there is a great waste with these fuels, as well as with common coal.

At the present prices, anthracite is stated to be an expensive sort of fuel, and sometimes there has been a difficulty in procuring it at all. It is, however, expected that the supply will in future be more regular, and the price lower, and many persons have found it to their interest to use this sort of fuel.

A striking instance of pretty general success is presented by the case of Manchester, a local Act for which borough requires that "furnaces shall, in all cases where the same shall be practicable, be constructed so as to consume or burn the smoke."

Joseph Heron, Esq., the town-clerk, in his communication on this subject states, that the practicability has been so often proved, and is now so easily demonstrated by reference to existing works, *that it is no longer disputed, but taken as admitted before the justices.*" In proof of the great improvement effected by the operation of the law, Mr Heron copies a table shewing the duration of smoke from twenty chimneys, as observed before the Act came into operation, as contrasted with their present state. From this table it will be seen, that at that time, fourteen of these chimneys emitted smoke during more than four and a-half hours out of nine; that six only emitted smoke for a shorter period; that three smoked almost without any intermission, *i.e.* more than eight hours out of nine; that five smoked more than seven hours, and eleven more than five, and that none smoked less than one hour and fifty minutes. Mr Heron now reports that the present state of the mills named in the table may be described in one word as most satisfactory; dense smoke is hardly ever seen, and smoke of any description is very rarely and only for very short periods observable from any of their chimneys. If ever seen to an objectionable extent, it is the result of carelessness on the part of the stoker or fireman, and an intimation from the Townhall at once secures the attention necessary to abate altogether the nuisance.

Many instances in proof might have been given: for exam-

ple: Messrs Cook and Co. (of the Oxford Road Mills) made many experiments for preventing smoke previously to the year 1845, and on being then summoned before the justices declared they had done all in their power to improve the state of their chimneys, and despaired of being able to make less smoke; they promised, however, to persevere, and try if anything further could be done, and the result soon was and has been since, that a stranger now looking at their chimneys might, and probably would, suppose that the mill was not working. It is understood that this satisfactory working of good apparatus, which before had failed, was obtained by making a small addition to the fireman's weekly wages when he succeeded in preventing smoke, and a large deduction when he failed.

Mr Heron does "not intend to say that the smoke nuisance is entirely abated. Much has been done, and the practicability of doing more has been abundantly proved; but of course in many cases difficulties are encountered, arising either from the want of boiler room or the want of money to make the necessary alterations, which it is difficult to surmount; and even where the alterations have been made, constant attention and watchfulness are required."

The Board regret to learn that with all the improvements effected, Manchester is still a very smoky place.

One main difficulty in effecting the object in question is the want of means to secure the attention and watchfulness required. It has been suggested, that it would be highly useful for this purpose to keep a number of constables on the constant watch. If a few men were stationed upon some of the highest buildings in London, for example, such as the Monument or the Victoria Tower, a very small number would be sufficient to keep all the chimneys of London under constant observation, and the officers would be near enough to identify any cases of breach of the law. It is only by some such plan of constant watching that this grievous nuisance can be quickly abated.

Mr Heron concludes by saying, "I feel that I may say, without fear of contradiction, that the result of our own experience has at least proved beyond dispute, that in few, if in any cases, can the impracticability of consuming smoke be with propriety urged in justification or excuse for the nuisance." From a man who has had such excellent opportunities for forming a correct opinion as the town-clerk of Manchester, such a statement is of the utmost importance. It is completely confirmed by the results of Mr Houldsworth's extended experience. Mr Houldsworth has proved by his own practice, that the duration of the nuisance or dense smoke from furnaces, of even the most simple and common construction, can be reduced from forty

per cent. of the whole time to five per cent. at little or no cost for the alteration of the furnaces, and with a positive saving of coals. He, therefore, represents that there need be little hesitation in bringing legislative pressure to bear sufficiently to lessen the evil in a great degree at once; while, if time be given for the gradual replacement of the old by new boilers, with double furnaces, and a union of the flues close behind the bridges, and provision for the admission of air at that point, the smoke nuisance may be almost entirely abated, and the manufacturing towns free from the reproach. Little, however, will be done without smoke inspectors to warn and teach, and to initiate legal proceedings where parties are refractory. From the communications received it appears, that nearly perfect success has been attained by various contrivances, and in many cases without any contrivance at all, by good stoking alone, and in others by the use of smokeless fuel, but that good success has rarely been attained without increased care by the stoker. Such care it is unreasonable to expect without in some way or other making it his interest to succeed, and at the same time providing him with a furnace by which he can succeed without very much additional labour.

A useful memorandum on this subject by J. A. Yarrow, Esq., C. E., will be found in the Appendix, wherein he shews that, by a weekly payment of five shillings in addition to wages, coke was saved to the value of £2, 16s. per week, the saving in the consumption thus repaying the increase in the wages eleven times over.

It appears that many contrivances for preventing smoke which are very successful at first, subsequently fall into disrepute. An explanation of many of these cases is afforded by the fact that, as already stated, good stoking is essential to success under any circumstances. This is secured while the invention is new, and while the inventor perhaps pays the stoker to make it succeed, but it fails when no special care is taken.

The communications concur in further representing that besides good stoking it is essential to have sufficient boiler surface, so that the requisite heat can be obtained from extended flues instead of from a fire unduly urged. Bad stoking and insufficient boiler surface are by many of the witnesses stated to be the main causes of smoke. Both of these causes it is evidently in the power of the manufacturer to remove, and the want of them cannot be justly pleaded in excuse for a public nuisance. It is, however, satisfactory to know that good stoking and sufficient boiler room are so economical to the manufacturer, that the cost of procuring those advantages is very soon repaid by the mere saving in fuel.

The evidence further shews that though special contrivances

are seldom essential they are often perhaps generally useful ; that there are almost innumerable patented inventions for this purpose, and that many of these are expired, of which, therefore, manufacturers may avail themselves if they please, without the infringement of any right.

Among such expired patents* which have enjoyed a high celebrity, may be particularly mentioned, Parke's split bridge, patented in 1820, since copied in numerous forms ; and Williams's Argand furnace, patented in 1839, instances of the almost perfect success of which are very numerous. This has been the type of numerous recent patents. It was with this that Mr H. Houldsworth conducted his celebrated experiments detailed to the Commons' Committee of 1841, by which he proved a saving by the prevention of smoke alone of 18 per cent. on the year's operations, and of 35 per cent. where particular care was taken. He states that a still greater saving might be attained had he had the command of more extended boiler surface. Mr H. Dirk, the late proprietor of this patent, states that any intelligent bricklayer may set up the whole apparatus for 30s. to 60s. for a thirty-horse boiler. That above 2000 have been erected, and wherever they are out of use it must be from sheer neglect. It is admirable for steam-boats, in proof of which ample evidence is given. Another very successful contrivance is the duplex furnace, *i. e.* two furnaces with one flue, each being fed alternately, so that one fire being always clear burns the smoke of the other. If this be combined as in Mr Fairbairn's furnace with a channel for the admission of air beyond the fuel, so that one furnace passes an excess of heated air and the other an excess of smoky gas (which burn as they mix), the prevention of smoke is said to be very complete and perfect as long as the stoker takes care to keep one fire always bright. If, however, as is often the case, he feeds them both together, the object is of course defeated. A furnace on this principle was patented by William Losh, as early as 1816, and another by Thomas Hill in 1839, both of which patents are expired.

How the existing patents for the same arrangement of fires differ from these and from each other has not been distinctly stated.

This is the plan said by Mr Heron to be most in favour in Manchester, where the success in preventing smoke has been very great. This construction of furnace is stated to have other important advantages besides that of permitting the smoke to be perfectly and economically prevented.

Very important evidence has been given of the success of various contrivances for self-feeding furnaces, for which there are three expired and three existing patents which have had a

* Oldest plans found often best and may be had without patent.

high reputation, besides others less known, but perhaps as deserving. Stanley's, Brunton's, and Bodmer's are expired patents, and Hall's, Jukes's, and Hazeldine's are existing ones. It is by Jukes's invention (which seems to be similar in principle to Bodmer's patent of 1834) that Messrs Truman, Hanbury, and Buxton have succeeded in preventing smoke from fourteen furnaces, with an annual saving of about £7000 a year to the proprietors, and with great advantage to the whole neighbourhood of Spitalfields. A declaration has been signed by eighty-three of the immediate neighbours, stating that they receive great advantage from the consumption of smoke.

"They say, we are now enabled to pursue our ordinary business with open windows, which before the introduction of the smoke consumer we could not."

Each of the three last-named are stated to be used at Price's candle factory with great economy and success.

There are a multitude of existing patents, which if they can be sustained will render it almost impossible to make any alteration in any furnace without infringing one or more of them; and though it is probable that the great majority of them cannot be sustained, that is a point to be decided by a Court of Law, not by an executive officer.

Again, though it would be in most cases comparatively easy to prevent the smoke, to know the *best* mode of doing so in particular cases is not only difficult, but doubtful, and can only be determined by careful consideration of all the circumstances.

Moreover, all experience has shewn that it is as much or perhaps more the mode of using a furnace, than its construction, which makes it succeed or fail.

The entire responsibility of so using it as to ensure its success should be fixed on those who have the entire control. It may be undesirable to give an authoritative recommendation of any particular plan, for this further reason, that none is the best in every case, and every opponent would endeavour to decry the plan recommended by authority, even though it might be the best in the great majority of cases. With reference to common fires there is reason to believe that one half of the coal usually burnt might be saved without any diminution of heat or material change in our habits. There is positive evidence that the like saving in the coal and for manufacturing purposes might be effected; for in numerous instances one half has been saved, while it is evident that the maximum economy cannot yet have been attained.

Some conception may be formed of the national importance of such a saving, if it could be universally effected, from the estimate that the annual cost of coal in this country *as paid by*

the consumer, including of course cost of carriage, &c. &c., is about £18,000,000.

As an illustration of the power of science to economize in this direction, it may be proper here to advert to the wonderful improvement in the working of Cornish engines. According to Mr Hopkinson, there is one engine now performing above twenty times the amount of work in proportion to the coal burnt, as was done before the great invention of Watt, and nine times as much as that great engineer effected.

The result in Cornwall has been obtained by an admirable adaptation both of boilers and engines for their purpose. Economy so vast cannot, of course, be generally effected, but the experience of numerous individuals shews that much may be done under ordinary circumstances. Thus Mr Parks found that he was able to make the same quantity of the same coal, with the same engine and boiler, do more than double work by merely regulating the draught, and Mr Palmer Budd reports that at his works at Ystalyfera, near Swansea, he is saving coal estimated at about 34,000 tons a year, worth nearly £7000, in a neighbourhood where coal is cheap. This great saving is effected by using the waste heat, and gases from blast furnaces, by a very ingenious and skilful, but simple arrangement. It is probable that if this single improvement were universally introduced, the saving to the country would exceed a million a year. A very valuable report on this subject by Professors Brurson and Dr Lyon Playfair was published in the Report of the British Association for 1845, and it is reported that in several blast furnaces both in Scotland and Staffordshire, the waste heat and gas is economically employed. Such instances are an answer to those who assert that the smoke of blast furnaces cannot be prevented.

It has long been a prevalent opinion that the very annoying and injurious quantity of smoke emitted from pottery kilns, could not be prevented without destroying the manufacture, but plans for this purpose have been tried with very encouraging success, both by Messrs Doulton and by Messrs Booth and Ainslie.

The patent for Messrs Doulton's very ingenious, simple, and effectual invention is not yet completed, and therefore is not yet published. It consists, however, of a mode for admitting above the fuel a regulated quantity of air, which becomes heated before mixing with the smoke. Though about half a ton of small coal is put on the fires of a kiln at once, producing in ordinary kilns an enormous cloud of smoke, equal to that of many factory chimneys, by this method no smoke at all can generally be seen, and never more than a very small portion of the usual quantity. Messrs Doulton report that the saving of

fuel is about one-fourth of that usually consumed, and the cost of the improvement a mere trifle, which would be quickly repaid by the saving effected. Messrs Booth and Ainslie's plan is recommended by Messrs Ridgway, who report that it answers perfectly, effects a great saving of fuel, and entirely prevents the smoke.

There seems no doubt that the same principle may be applied to bakers' ovens or any similar purpose where a heated cavity is wanted. Mr Booth also expects to apply his furnace for this purpose, and it is stated that Williams', Prideaux's, Stevens's, and other patents have been so applied with economy and success.

The waste of fuel in other furnaces, and especially in common fire-places is, however, still greater than for boilers, and the same measures which are requisite for the consumption of smoke, will in these also be economical, by ensuring the complete combustion of the fuel, but to introduce improvement here will be more difficult, first, because domestic fire-places are many times as numerous as manufacturing furnaces; but chiefly because those to whom they belong (house owners) are not the persons who would receive the direct benefit of the economy and comfort from their improvements.

As to fires for cooking, great economy with prevention of smoke, and great additional facility of cooking might be attained by the substitution of French, Belgian, or American stoves for common kitchen ranges. An experiment continued for two years has been reported to the Board, showing that all the cooking for a family of four may with one of the Belgian stoves be done by the consumption in six months of one chaldron of coke costing 13s., or about a penny a day. No special care was taken to save fuel, the fire was kept up about fifteen hours every day, and as much fuel burnt as was desired. The common introduction of such stoves, of which that called the cottager's stove is a variety, would tend materially to the improvement of the art of cooking, an art more intimately connected with health, comfort, and economy, than even that of medicine. For common fires, the fire-place recently recommended by Dr Arnott, is probably the improvement most likely to recommend itself to English habits and feelings. The prevention of smoke is complete, the economy of fuel considerable, and the stove itself, cheap, easy to manage, and not materially different in appearance from that in universal use. The principle is that of supplying the fresh fuel at the bottom instead of putting it on at the top of the fire. The coal is in a box nearly air-tight below the fire; the tar, vapours, and gases, produced by the decomposition of the coal pass through the incandescent fuel above, and burn when they reach the air. Fresh fuel is supplied, as

wanted, by pushing up the coal from below. The draught is regulated by a simple valve, and the useless escape of heated air up the chimney diminished. The fire burns quite free from smoke, the burnt air is safely carried away and fuel economised. Though there may be cheaper modes of warming, there is probably none which could be so easily adapted to existing fireplaces, and combining so many advantages as this ingenious invention.

Dr Reid has suggested that smoke from domestic fires might be prevented by the use of coke, which, if manufactured so as not to abstract the gas entirely, would make a very pleasant fire, and be not so difficult to light as if made with common gas coke. It has also been suggested that very useful and pleasant household fuel might be cheaply made by means of any of the engine furnaces which act by passing the coal by mechanism from the front to the back of the furnace. The fuel at the back of such furnaces is coke, or rather half-burnt cinder. If such a speed were given to the apparatus as would allow of the smoke-producing part of the coal to be burnt off, and the rest passed half-burnt into a box behind, all the heat of the first part being used by the manufacturer, he would be able to sell the latter part at a very moderate price.

The use of gas either alone or in combination with coke has been recommended as a means of preventing smoke, but has not yet been managed in a way to be sufficiently economical to command general acceptance. If gas companies were to let fittings to their customers at a moderate rental instead of requiring them to provide them themselves, a great impediment to the general use of gas both for lighting and for warming would be removed.

Though gas is a dear source of heat, the ease with which it can be lighted and the exactness with which it may be regulated, so reduce the waste of heat as to render it for many purposes economical. Thus when heat is wanted for cooking alone; or for short periods only, gas is cheaper than coal. As gas for heating is wanted chiefly by day and would not therefore require the pipes to be enlarged for its conveyance, it might be sold with profit at less than the ordinary price, as nearly all received above the cost of making would be profit.

The advantage to the public of preventing smoke by the adoption of one or more of these means need not be insisted upon. Every one can appreciate the advantage, if London were as completely free from smoke as are many continental cities.

The following are submitted as conclusions deduced from the evidence obtained:—

1. That the emission of smoke is the effect and may be taken

as the proof of imperfect combustion, and is therefore always attended with waste of fuel.

2. That the fuel wasted is not only the visible smoke, which is unburnt carbon, but generally a far larger portion in the form of gas, both common coal gas and that called carbonic oxide, which is only half-burnt carbon, and which, therefore, has not produced the heat which it would have generated if it had been perfectly consumed.

3. That the chief impediment to the prevention of smoke in manufactories is the insufficient boiler surface in proportion to the steam required; a deficiency which causes waste in two ways; first, because much of the heat produced escapes up the chimney uselessly, and next, because this deficiency has to be made up by overfiring, whence imperfect combustion and consequent waste of fuel.

4. The employers of furnaces labour under great difficulty as to the best and most economical use of fuel, because ordinary makers of furnaces seem to be guided in their construction by little better than empirical rules, instead of acting upon well-established scientific principles, or the results of accurate experiments.

5. That, notwithstanding this great difficulty, many persons have succeeded in entirely preventing the escape of visible smoke, except while firstlighting their furnaces, and many others have reduced the time during which smoke is emitted to a small fraction of its former amount.

6. That experience has fully proved that there is no truth in the common allegation, that if smoke be prevented, there must be increased difficulty in getting up and maintaining steam.

7. That successful modes of preventing smoke, if there be proper boiler surface, may be adopted without the infringement of any patent right, the methods in question not having been patented, or the patents having expired.

8. That, notwithstanding the great and obvious advantages of perfecting the combustion of fuel, and the certainty that the cost of doing so will be amply repaid by the saving effected, such is the indisposition of practical men to depart from the beaten track, that nothing but the force of law is likely to ensure the care and attention necessary to protect the public from a grievous nuisance, the manufacturers themselves from heavy unnecessary expense, and the national resources from grievous waste of fuel to the amount of millions a year.

9. That though the absolute and immediate prohibition of smoke could not be enforced, without compelling most of the owners of furnaces to incur very heavy expenses, its reduction to a very small amount may be effected with comparative ease, and with very great benefit both to themselves and others; while

it cannot be denied, that any who produce more smoke than others who use fuel for the same purposes, do produce more than is practically necessary.

10. That the enforcement of smoke regulations can be most easily and quickly effected by the appointment of constables to keep a regular and constant watch upon all chimneys liable to emit much smoke; and that the prevention of smoke will be more quickly and certainly effected by constant supervision and immediate information of any breach of the regulations, than by heavy penalties irregularly imposed.

11. That great facility in the prevention of smoke would be afforded by the publication of the specifications and descriptions of patented and other inventions for the prevention of smoke, by which those interested could be informed what they could and could not do in this matter, without infringing upon any patent right.

12. That great facility would also be afforded by the appointment of officers specially qualified, and *not connected with any patentee or manufacturer of boilers or furnaces*, to superintend the police officers employed to suppress the nuisance of smoke, and to advise owners of furnaces how best to comply with the provisions of the law, and to report upon cases of its infringement.

COPY of a LETTER from JOSEPH HERON, Esq., to the GENERAL BOARD OF HEALTH.

MANCHESTER, *November 17. 1853.*

MY LORD AND GENTLEMEN,—The clause in the Manchester Borough Police Act (7 & 8 Vict. c. 40, s. 75, 1844), under which proceedings are taken by the corporation to cause a diminution of smoke, requires that the furnace “shall, in all cases where the same shall be practicable, be constructed so as to consume or burn the smoke.”

The practicability has been so often proved, and is now so easily demonstrated by reference to existing works in which the consumption is as nearly as possible perfect, that it is no longer disputed, but taken as admitted before the justices.

The unsatisfactory state of the furnaces generally throughout the city at the time the Borough Police Act was passed, is sufficiently evidenced by the tabular statement submitted, which includes some of the largest and most important establishments in Manchester, and such returns may be taken as shewing the then state of the furnaces of the remainder of the works throughout the city.

It may be stated that the corporation have declined in all cases to make any suggestions whatever as to the means or plan which should be adopted for consuming the smoke, but have left the parties to make their own inquiries and to take such measures as they might ascertain by inquiry to have been the most successful ; it has been considered that if any party could have urged that the plan suggested by the corporation had been unsuccessfully adopted, the corporation would have had some difficulty in taking further proceedings. The best position for the corporation to take, was to be able in all cases to point to the mills and works of a similar description, where the smoke was effectually consumed, as an answer to any suggested difficulty on the part of any parties summoned before the magistrates.

To the honour of the proprietors of works, it may be stated that they have cordially seconded the efforts of the corporation, and have willingly incurred in many instances heavy expenses to secure the results of which Manchester has good reason to be proud.

The present state of the mills named in the table may be

described in one word as most satisfactory : dense smoke is hardly ever seen, and smoke of any description is very rarely, and only for very short periods observable from any of their chimneys. If ever seen to an objectionable extent, it is the result of carelessness on the part of the stoker or fireman ; and an intimation from the town hall at once secures the attention necessary to abate altogether the nuisance.

The difference between the smoke now emitted, and that which once issued with little interruption from morning till night, can only be properly appreciated by those whose attention was directed to the subject before the passing of the Police Act.

The smoke now called "dense" is light in comparison with the huge volumes of black smoke which then issued forth of a character so heavy as to be scarcely able to ascend, and which formed clouds over the localities in which the mills were situate in every part of the city prior to 1845.

The most popular plan for preventing smoke in use in Manchester is the adoption of boilers with two furnaces which are fired alternately.

Many persons were formerly in favour of the plan of judiciously admitting air through valves into the furnaces, and thereby securing, as contended, an important saving of fuel, whilst others have objected, that the result was a loss of steam as well as of fuel ; one fact is, however, very significant, viz., that most of the large mill-owners who have found it necessary to put down new boilers have successfully adopted those made on Mr Galloway's plan, with two furnaces, so as to fire alternately, and render the admission of air by means of valves unnecessary.

The most recent instance is at the very large and important establishment of Messrs Birley, who have put down eight new boilers, six of which are constantly working, and two kept in reserve. All the flues are carried into one chimney. On the 11th November instant, the inspector took an observation of an hour and a half's duration, during which no smoke was seen. Mr Richard Birley states that notwithstanding the expense incurred, the arrangements and alterations which the firm had made were quite satisfactory, and that certainly there was no loss in preventing smoke ; and further, that if offensive smoke was ever emitted, it must be the result of carelessness on the part of the stokers, for that, if the furnaces were fed according to the instructions given, smoke could not be made. Messrs Birley had previously made many ineffectual attempts, at considerable expense, to abate the nuisance ; they had been repeatedly proceeded against by the Corporation, and the nuisance created by their chimneys was intolerable until they made their last alterations.

Messrs Cook and Co. (of the Oxford Road mills) made many experiments for preventing smoke previously to the year 1845, and on being then summoned before the justices, declared they had done all in their power to improve the state of their chimneys, and despaired of being able to make less smoke; they promised, however, to persevere, and try if anything further could be done, and the result soon was, and has been since, that a stranger now looking at their chimneys might and probably would suppose that the mill was not working.

The mills of Mr Hugh Beaver furnish another striking proof of the practicability of preventing smoke; for instance, instead of finding, as heretofore, the chimney vomiting forth black smoke from morning till night, the chimney is now as free as those of the Oxford Road Twist Company. Mr Beaver states, that not only is there no loss, but that he has experienced an important saving by adopting Galloway's boilers. The Oxford Road Twist Company have adopted the same kind of boilers, and many other mill-owners might be named to whose works the same remarks would apply.

Objections have been urged on the ground of the difficulty of preventing smoke at print works, calenderer's works, and other such premises. In the case of Mr Thomas Ball, calenderer, Chorlton Street, dense smoke issued from his chimney for thirty-six minutes in the course of an hour and a half, but since he has put down one of Galloway's boilers the chimney is, and has been, very satisfactory, and I am not aware that any greater difficulty is experienced than in any other establishment.

The chimney of Messrs Gallemore, printers, Ardwick, has been uniformly satisfactory, nor have they complained of any difficulty in consuming their smoke.

Messrs Heald, Wilson, and Co., Messrs Hoyle and Sons, Messrs Ainsworth, Sykes, and Co., have also made great improvements, and fully shown the practicability of working their several printing establishments without allowing the amount of dense smoke to escape, which was formerly greatly complained of.

From the table it will be seen that prior to 1845 it was no unusual thing for dense smoke to issue for five or six out of nine hours. Now all the manufacturers who have paid attention to the subject, and co-operated with the Corporation (and there are few who have not done so), are convinced that there is no necessity for the emission of dense smoke, and are annoyed whenever they perceive any such escaping from their chimneys, being fully satisfied that in all cases it is the result only of negligence on the part of the fireman.

With respect to dye works, Messrs Douglas and Co. in Old

Garratt, and Mr Matthew Brignall, of the Mount Dye Works, have entirely satisfied the Council; and many other dyers whose chimneys emitted vast quantities of smoke, especially in the neighbourhood of Ardwick, have effected great improvements.

The same remarks will apply to all other firms using steam power, and also to brewers. Considerable difficulty was experienced in the case of Mr Joseph Bleackley, of Downing Street, Ardwick; and also Messrs Collins and Chester, whose chimneys caused great nuisances to the neighbourhood in which they are situated; but now offensive smoke is rarely seen, and complaints from the neighbours, which, prior to the arrangements made for burning the smoke, were constant, are never received at the Town Hall.

I do not intend to say that the smoke nuisance is entirely abated. Much has been done, and the practicability of doing more has been abundantly proved; but of course in many cases difficulties are encountered, arising either from the want of boiler room or the want of money to make the necessary alterations, which it is difficult to surmount, and even where the necessary alterations have been made, constant attention and watchfulness are still required.

The object of the Corporation has been to interfere only to such an extent, and in such a manner, as would secure the approval and enlist the co-operation of the proprietors of works; and so far the Council have great reason to be satisfied with the result.

If I can furnish the Board with any further information which is likely to be useful, I shall be most happy to do so; but I feel that I may say, without fear of contradiction, that the result of our experience has at least proved beyond dispute that in few, if in any, cases can the impracticability of consuming smoke be with propriety urged in justification or excuse for the nuisance. I am, &c.,

(Signed)

JOS. HERON,
Town Clerk.

To the General Board of Health,
Whitehall, London.

COPY of a LETTER from H. HOULDSWORTH, Esq., to the GENERAL BOARD OF HEALTH.

MANCHESTER, *December* 1853.

In replying to the inquiries of the Board of Health, dated Whitehall, November 5. 1853, respecting the means of consuming smoke, "generated by different descriptions of fur-

naces," I would class the furnaces on which I purpose to remark under two heads:—

1st, Those in which the coals are fed or thrown on by hand labour ;

2nd, Those in which the coals are thrown on or fed by the regular action of mechanical contrivances.

But before entering into the merits of the different kinds of furnaces, I would briefly direct attention to the essential principles on which the non-production of smoke depends, and by the knowledge of which the comparative merits of different furnaces may be estimated.

It must be kept in view—

That smoke is the result of imperfect combustion, arising either from a deficient supply of air or a want of heat in the furnace ;

That all effective means of lessening smoke resolve themselves into modes of securing the union of a sufficient quantity of air with the gases evolved during combustion, at or near the hottest parts of the furnaces ;

That neither the admission of air to the gases without the degree of heat to inflame the mixture, nor a high heat without the presence of air, will prevent smoke ;

That in a steam boiler and other close furnaces smoke is generally occasioned by an insufficient supply of air, but in common house fires it usually results from a want of heat where the gas mixes with the air.

Keeping these principles in view, a brief reference to the ordinary construction of a steam boiler and other close furnaces will show the cause of the dense smoke usually produced.

Such furnaces usually consist of a chamber having a floor of grate bars for the reception of the coal, and the admission of air, and furnished with doors fitting more or less tight to admit the fuel, which is thrown in at intervals of time by means of a shovel. As no other provision is made for the admission of air, none practically enters but up through the grate and mass of fuel upon it.

It results from this arrangement that the least air enters when the most is wanted, for, when fresh coals are thrown on, the greater depth of fuel on the bars impedes the entrance of air just when the smoke is being evolved in the greatest quantity ; and precisely as a house fire recently mended with small coal, gives off a volume of dense smoke, till an opening is made with a poker for the passage of air through the mass of fuel, and the heat becomes sufficient to kindle and convert the mixture of gas and air into flame, so does the close furnace, in the absence and for want of a due supply of air, vomit forth dense

smoke after every charge of fresh coal, till the bituminous part of the fuel has all passed up the chimney.

The simple remedy for this evil is to admit a supplemental quantity of air into the body of the furnace at other points than through the grate; and if the aggregate area of the apertures for this supplemental air be made equal to from $1\frac{1}{2}$ to $2\frac{1}{2}$ square inches for each square foot of grate surface, sufficient air will enter to combine with the bituminous gases given off by the usual varieties of coal; and three-fourths of the dense smoke will be prevented, with a saving of at least one-sixth in the consumption of coal in the same furnace, for the same work done.

Experiments carefully conducted with a wagon-shaped boiler made by Bolton and Watt proved this incontestably, both by the quantity of water evaporated and by the indications of pyrometers in the flues. The details of these were given by me in evidence before the parliamentary committee on "Smoke Prevention" of 1843, and will be found in the printed evidence between pages 96 and 108, and in Appendix No. 5, page 201.

The comparative temperature of the leading flue, and the quantity of water evaporated by a given weight of coals, with and without supplemental air, were as follows:—

	Degrees of Heat.	Gallons evaporated.
When no air was admitted except between the grate bars,	973°	992
When a constant supply of air was admitted by apertures of an area equal to $2\frac{1}{2}$ square inches for every square foot of grate,	1165°	1263

The general results shewed an average gain in evaporation, when supplemental air was admitted, of 35 per cent. and of 32 per cent. in the steam produced in a given time.

These experiments led to the fitting-up of all the furnaces of the firm with supplemental air flues and valves, and sight holes or flue windows to enable the fire tilters to see into the interior of the flues, by which they could adjust, if thought necessary, the quantity of air admitted to the varying condition of the fire.

With these sight holes, and the air valves so situated that the fire tilter can regulate the one while looking through the other, there is no excuse in this construction of furnace for making dense smoke, except occasionally at the moment of poking or feeding the fire; and then, on closing the furnace doors, dense smoke ought to cease instantly.

The general result of the admission of air, as here described, was an average saving in the three years following its adoption by the firm of 18 per cent. in the quantity of coals consumed,

and a diminution of at least three-fourths of the dense smoke previously produced.

These results have been confirmed by long experience, and if furnace owners refuse or neglect to provide the means of admitting air at some other and additional point than between the bars, and what is of great practical importance, if they do not also provide convenient sight holes to enable the fire tenters to see the interior of their flues, they have no just cause to complain if compelled by parliamentary enactment to adopt these or other means of abating the nuisance.

It is proper to notice, however, that there is a great practical difference between the total prevention of smoke where pit coal is used, and an abatement of eight-tenths of the nuisance. The one is all but practically impossible, looking to the various conditions under which heat has to be generated ; the other is practically easy in almost every case. Thus, there will always be smoke when the feeding is intermittent, that is, while fresh coals are being thrown on by hand labour, and when the fire requires levelling, poking, or cleaning ; and again when the smoke arises from want of heat, which is the case on commencing to urge a fire that has slumbered through the night, or the brisk action of which is only wanted at intervals. In such cases smoke is frequently unavoidable, for a longer or shorter time, according to the coldness of the furnace.

This brings us to an improved construction of furnace, which is becoming general in Lancashire, wherein the reduction of temperature occasioned by a heavy charge of cold fuel is provided against, by constructing the furnace with two separate grates, which are charged alternately. In these furnaces the flues from the two grates unite close behind the bridges, so as at that point to mix the smoke-gases evolved from the fresh fuel on the one grate with the current of heated gas proceeding from the red-hot fuel of the other. By this means so high a temperature is maintained that, when a due supply of air is admitted at the point of junction, smoke is almost wholly prevented. It is only to be regretted that some of the makers have such a morbid antipathy to the introduction of air anywhere but up through the fire, that no other provision is made for its admission ; and the effect of the double grate is in part neutralised for the want of the chemical element essential to convert bituminous gases into flame.

This notion, together with its counterpart, that smoke can be burnt by heat without air, and the too common practice of the fire tenters to charge the two furnaces at once, that they may secure for themselves longer intervals of rest, prevail so extensively as to have deprived the public of much of the benefit which this construction of furnace might afford in the preven-

tion of smoke. These obstacles would soon yield to parliamentary compulsion, if smoke inspectors were appointed, and the law were judiciously framed, so as to require progressive improvement and nothing impracticable.

With regard to furnaces of the second class, in which the coal is fed continuously by mechanical means, I have little personal experience. The advantage of continuous feeding is, that the action of the furnace is less interrupted than when the fire doors are thrown open every few minutes to supply coal; and when the throwing on of the fuel is continuous, a uniform admission of supplemental air corresponds better with the general state of the fire. Of the two plans most generally adopted, that of Mr Jukes appears to be the most perfect. The coal is not bruised in the feeding, as is the case when fanners are employed to distribute it upon the grate; and the progressive motion of the grate, and continuous discharge of the ashes, supersedes the poking, stirring, and cleaning out of the fire, which all stationary grates, whether fed mechanically or otherwise, require. If, in using Jukes's furnace experience shews that the links of the travelling grate preserve their shape, and continue to work freely irrespective of heat and quality of fuel, then I should be inclined to say that by means of this mechanism and the introduction of a due supply of air (which the motion itself would facilitate), smoke might more perfectly be prevented than by any other means.

From what has now been said it will be seen that I view the smoke nuisance as one that can and ought to be abated, and that I believe it owes its continuance, in any aggravated degree, much more to ignorance and prejudice than to any inherent practical difficulty in preventing a prolonged continuance of dense smoke. To remove the one, I cannot too strongly recommend the perusal of Mr Chas. Wye Williams' treatise on combustion, and to dissipate the other, a gentle legislative pressure brought to bear over the whole manufacturing districts through the instrumentality of smoke inspectors. Their business should be not only to warn and report, but also to spread the knowledge of the various successful means of abating the evil, and of the economical results obtained where such means had been most successfully applied.

P.S.—Since the foregoing was written, I have caused diagrams to be made of the smoke which issued from one of our chimneys on three different days, to shew the effect of supplemental air.

Those dated the 23d and 25th November were obtained without the knowledge of the fire tender, and that of the 1st December with his knowledge, and after a caution not to make smoke,

and with instructions to admit a constant supply of air during the period of observation by an aperture equal to $2\frac{1}{2}$ square inches for every square foot of grate.

The dense smoke is indicated by extending the shade to the full width of the columns, and its duration by the perpendicular depth of the same; the space between each horizontal line representing one minute of time.

Smoke that can be seen through at the point of issue of the chimney is represented by a lighter and narrower shade till the moment of its disappearance altogether.

The period of observation was six hours of active work each day.

The duration of dense smoke was as follows:—

	Minutes of dense smoke.	Per-centage of whole time.
When no air was admitted, except between the bars,	143	$40\frac{1}{2}$
A medium quantity of supplemental air admitted, and no care on the part of the fire tender; the ordinary every-day working of the furnace,	49	$13\frac{1}{2}$
A full quantity of supplemental air constantly admitted, and the fire tender's vigilance stimulated by a caution,	20	$5\frac{1}{2}$

From the foregoing it is manifest that a chimney with three furnaces working into it, of the most common construction, need not produce dense smoke for more than five minutes per hour.

I am, &c.

(Signed)

H. HOULDSWORTH.

To the General Board of Health,
Whitehall, London.



